

# **July 1996**

## **Preliminary Data Summary**

by      Field Research Facility

U.S. Army Corps of Engineers  
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# Preface

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This report provides a summary of basic oceanographic, meteorological and bottom profile data for the month. The data were obtained as part of the Measurements and Analysis work units at the U.S. Army Engineer Waterways Experiment Station, Coastal Engineering Research Center's Field Research Facility (FRF) in Duck, North Carolina. The FRF staff collected and analyzed these data. These summaries are intended to make the data readily available to all FRF users, and comments on their content and usefulness are invited.

**Data from these reports are now available via the World Wide Web at  
<http://www.frf.usace.army.mil>**

These web pages contain general information about the Field Research Facility and data from 1980 to the present.

Your comments and criticisms are welcome.

# Introduction

## 1

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The U.S. Army Engineer Waterways Experiment Station, Coastal Engineering Research Center's (CERC) Field Research Facility (FRF) is located on the Outer Banks of North Carolina, near the village of Duck (Figure 1).

The FRF research program provides a means for obtaining high-quality field data, particularly during storms, in support of the U.S. Army Corps of Engineers' coastal engineering research missions. The research pier is a reinforced concrete structure supported on 0.9-m-diam steel piles spaced 12.2 m apart along the pier's length and 4.6 m apart across the width. The pier deck is 6.1 m wide and extends from behind the duneline to about the 6-m water depth contour at a height of 7.75 m above the National Geodetic Vertical Datum (NGVD) of the year 1929.

One of the responsibilities of the FRF research program is the collection, analysis and dissemination of data on local bathymetric, oceanographic, and meteorological conditions. This summary is intended to provide basic data as soon as possible after they are obtained. Questions and/or comments concerning the data may be directed to Mr. Clifford F. Baron at (919) 261-3511 ([c.baron@cerc.wes.army.mil](mailto:c.baron@cerc.wes.army.mil)).

Chapter 2 presents the meteorological data; Chapters 3 through 6 present oceanographic data; Chapter 7 presents nearshore profiles and bathymetry; and Chapter 8, if included, documents special events that occurred at the FRF during the month.

Table 1 is a list of instruments used and their operational status during the month. Figure 2 shows weather and ocean conditions for the month. Table 2 and Figure 3 identifies the location of the instruments. The water depths at the wave gauges and current meters vary and may be determined from information contained in Figure 9. Other installation information is contained in Table 1.

Times given in the report are referenced to Eastern Standard Time (EST).

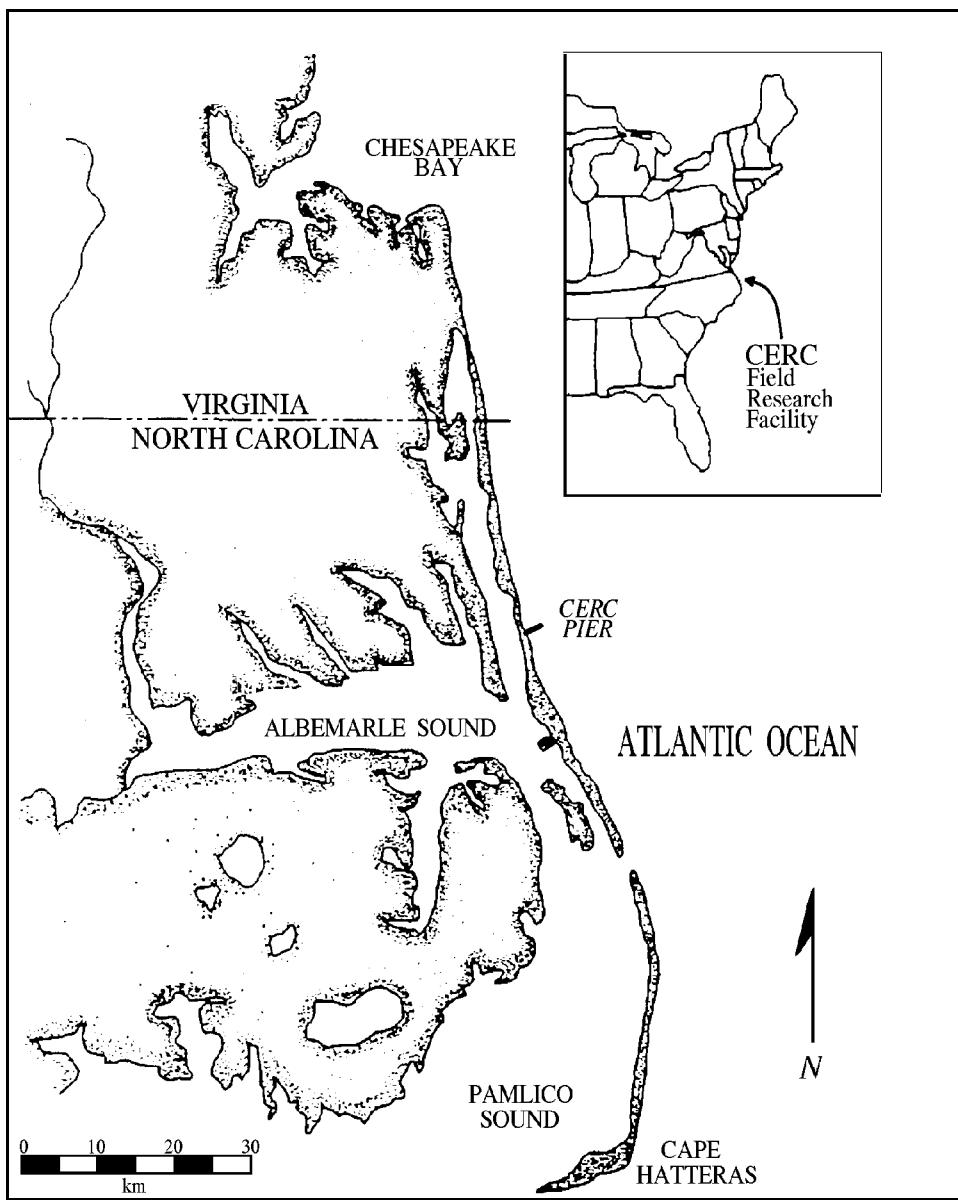


Figure 1. FRF Location Map

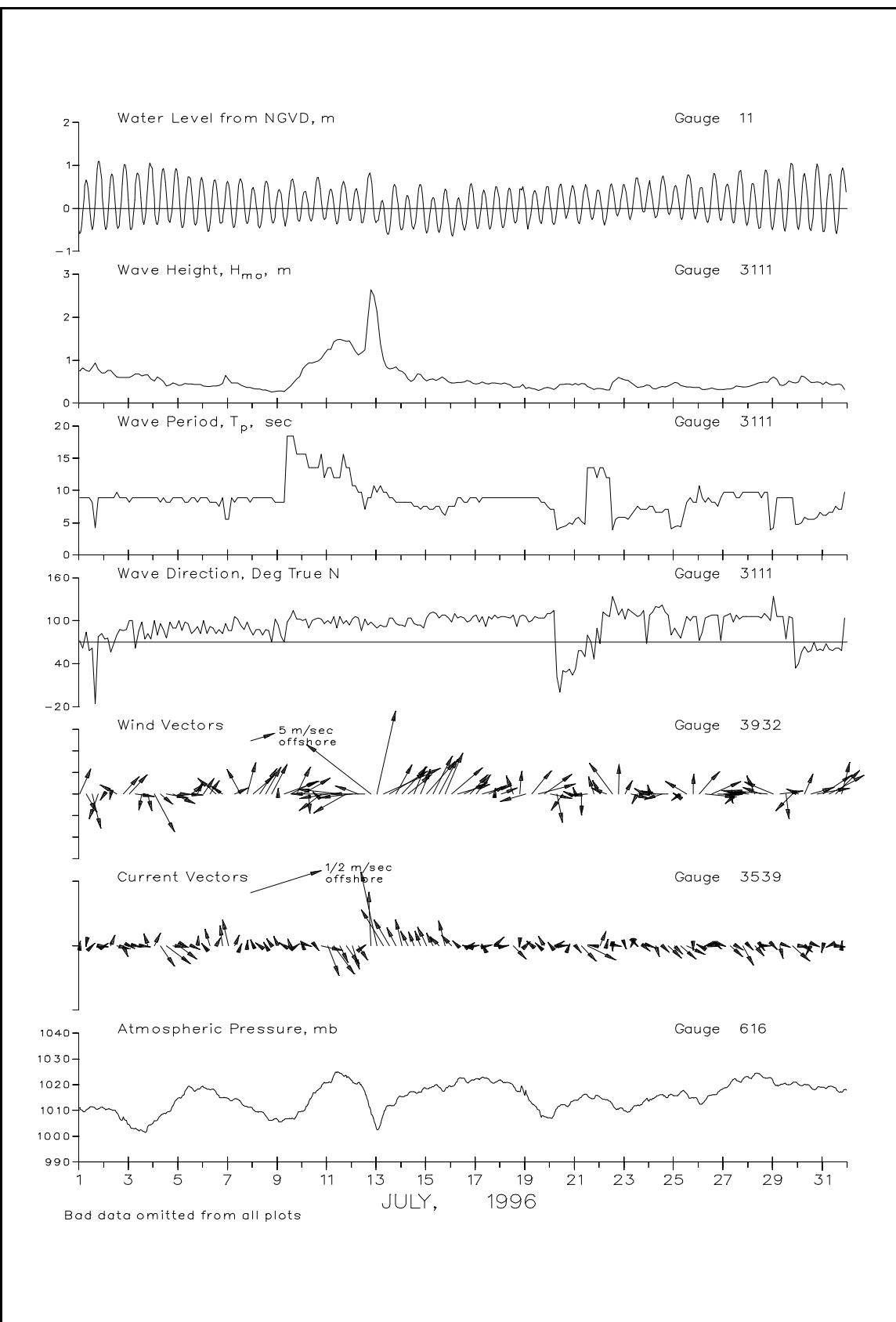


Figure 2. Month at a Glance

**Table 1**  
**Instrument Status/Data Availability**

		July 1996																																				
		Day of the month																																				
Gauge ID	Description/Remarks	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1						
616	Atmospheric Pressure	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*			
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*			
604	Precipitation	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*			
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*			
624	Air Temperature	-	-	/	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*			
		Data Collected	-	-	/	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*			
3932	Anemometer	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*			
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*			
641	Pressure Gauge on FRF pier	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		
625	Baylor staff on FRF pier	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	/	*	*	*	*				
		Data Collected	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	/	*	*	*	*	*				
3111	8 Meter Array 309 m north of FRF	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	/	*	*	*	/	*	*	*	*	*	*	*	*	*	*	*	*	*
111	Pressure Gauge center of 8 Meter Array	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
630	Waverider buoy 4.0 km offshore	-	-	/	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
		Data Collected	-	-	/	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	/	*	*			
3539	Current meter 343 m north of FRF pier (1.6 km offshore)	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
11	NOAA tide gauge at end of pier	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		
Visual Observations (daily oceanographic and meteorological observations)		Daily observation	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*			
Gauge Status		*	= Operational	/	= Partial	-	= Non-Operational																															
Data Collected		*	= All	/	= Partial	-	= None																															
Visual Observations		*	= Complete	/	= Partial	-	= None																															

**Table 2**  
**Gauge Locations**

Gauge*	Description	* Latitude	* Longitude	* FRF Coordinates	* Gauge Depth	* Water Depth
ID *		* Degrees N	* Degrees W	* CrossshoreT Longshore*	NGVD, m	* NGVD, m
616	* Atmospheric Pressure*	36 10' 57.03"	* 75 45' 5.50"	* 11.60	* 569.00	* -----
3932	* Anemometer	* 36 11' 1.23"	* 75 44' 43.07"	* 585.20	* 517.30	* 19.50
641	* Pressure Gauge	* 36 10' 57.71"	* 75 44' 56.23"	* 239.11	* 516.64	* -1.64
625	* Baylor Staff	* 36 11' 1.04"	* 75 44' 43.72"	* 568.00	* 516.64	* Surface
3111	* 8 Meter Array North	* 36 11' 19.14"	* 75 44' 36.41"	* 915.23	* 990.16	* -7.50
	* 8 Meter Array South	* 36 11' 11.28"	* 75 44' 33.28"	* 914.20	* 735.37	* -7.42
	* 8 Meter Array East	* 36 11' 13.70"	* 75 44' 32.56"	* 954.51	* 800.58	* -7.62
	* 8 Meter Array West	* 36 11' 12.48"	* 75 44' 37.11"	* 834.66	* 800.37	* -6.98
111	* Pressure Gauge in center of 8 M Array	* 36 11' 14.06"	* 75 44' 34.39"	* 914.43	* 825.52	* -7.76
630	* Waverider Buoy	* 36 10' 5.10"	* 75 41' 59.30"	* 3934.96	* -2400.81	* Surface
3539	* Current Meter	* 36 11' 23.57"	* 75 44' 9.12"	* 1605.80	* 907.60	* -11.60
11	* NOAA Tide Gauge	* 36 11' 1.25"	* 75 44' 42.60"	* 596.49	* 514.20	* Surface
R	R	R	R	R	R	R

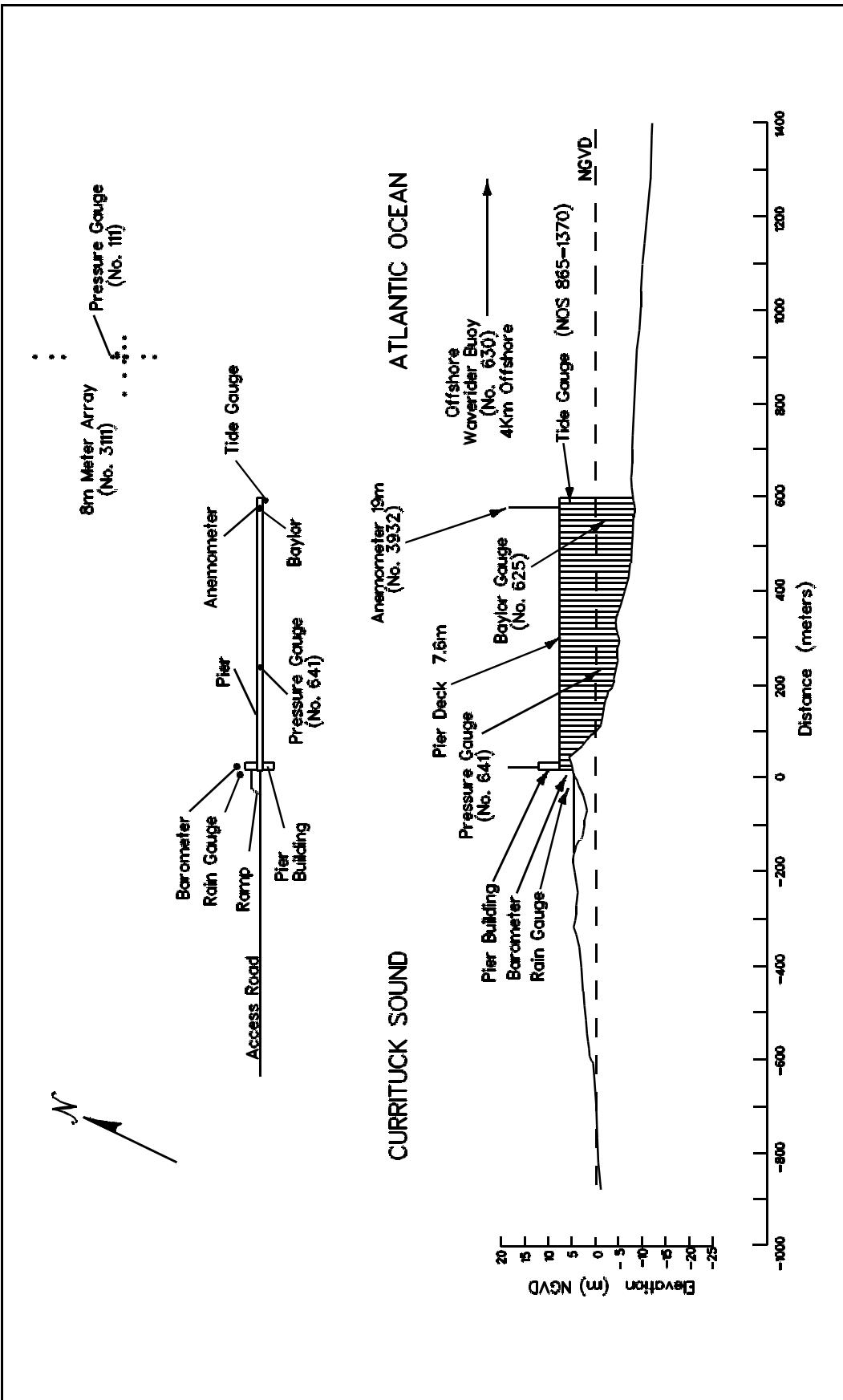


Figure 3. Instrument Locations, Elevations From NGVD

# Meteorological Data

## 2

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A variety of instruments have been installed at the FRF (Figure 3) to monitor the meteorological conditions. The data presented in Table 3 are collected and stored using a Digital Equipment Corporation VAXstation 4000. For each instrument identified in Table 1, a log is maintained and the records are stored for future reference.

Winds were measured at the end of the pier at an elevation of 19 m using a WeatherMeasure Skyvane anemometer. Monthly resultant wind speeds and directions (Figure 4) are determined by vector averaging the data. Wind directions (Table 3) indicate where the wind is coming from. Temperature and atmospheric pressure means (Table 3) are the average of the values presented for the month. Total precipitation is the sum for the month.

The following may be useful for converting the data in Table 3 to other frequently used units of measurement:

1. Millimeters (mm) to inches (in.) -  
 $mm \times .03937 = in.$
2. Millibars (mb) to inches of mercury (in. Hg) -  
 $mb \times 0.02953 = in. Hg$
3. Degrees Celsius (C) to degrees Fahrenheit (F) -  
 $(C \times 9/5) + 32 = F$
4. Meters per second (m/s) to knots (kn) -  
 $m/s \times 1.943 = kn$

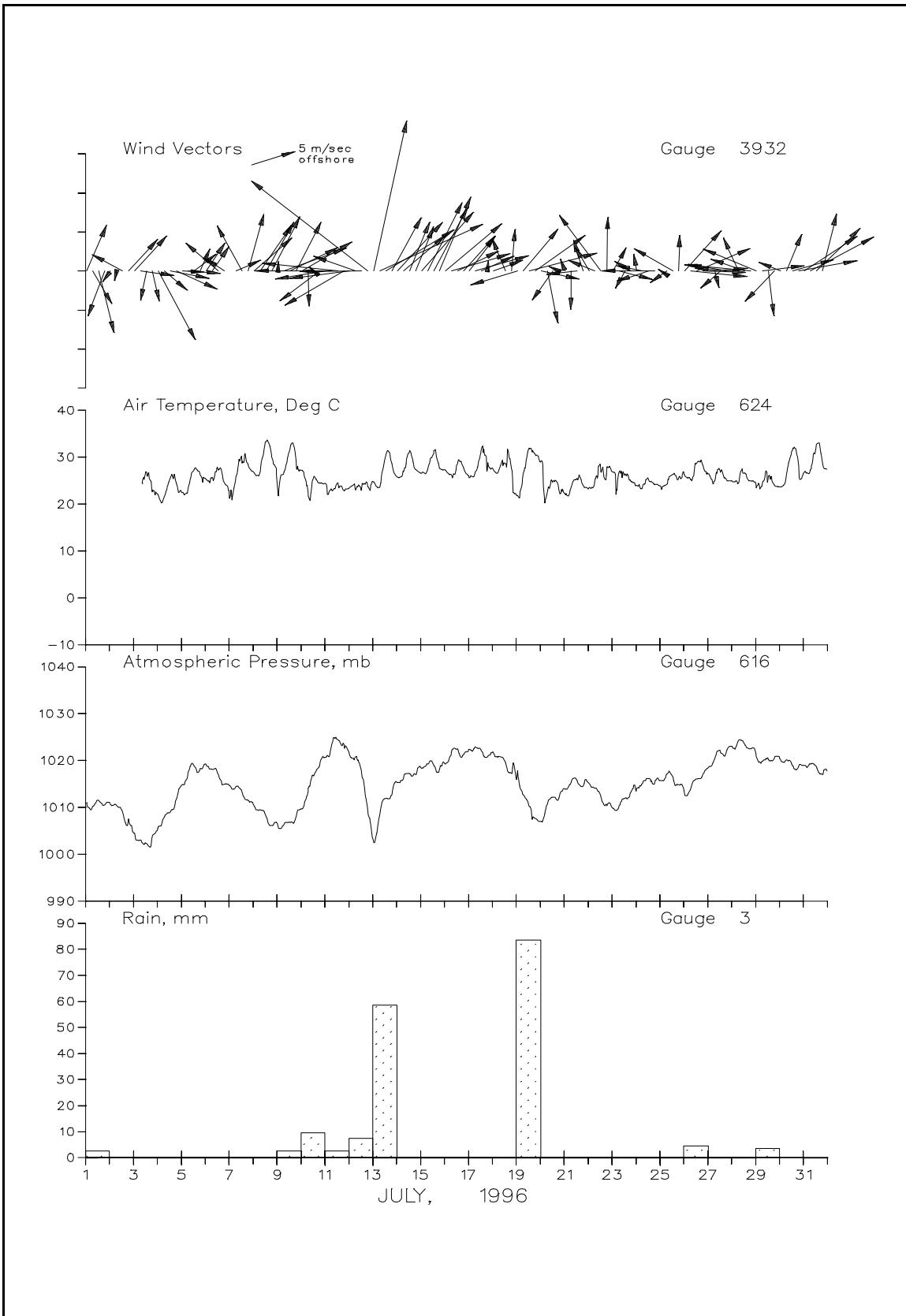


Figure 4. Meteorological Monthly Summary

**Table 3**  
**Meteorological Data**

Jul 1996						
Day	Hour	Wind Speed m/sec	Wind Direction deg TN	Temperature deg C	Atm Pressure mb	Precipitation mm
1	100	6	200		1011.0	0
	700	5	333		1010.2	3
	1300	8	347		1011.5	0
	1900	6	17		1010.7	0
2	100	2	32	inoperative	1010.7	0
	700	1	10		1010.5	0
	1300	4	122		1009.1	0
	1900	5	218		1007.5	0
3	100	6	218		1004.5	0
	700	4	278		1003.1	0
	1300	4	9	26.8	1002.3	0
	1900	4	1	22.6	1003.8	0
4	100	10	335	21.8	1006.0	0
	700	3	314	21.7	1008.0	0
	1300	4	282	25.6	1009.1	0
	1900	5	297	24.4	1011.9	0
5	100	2	273	22.5	1014.9	0
	700	4	274	23.4	1017.5	0
	1300	3	228	27.3	1018.9	0
	1900	3	200	26.2	1018.3	0
6	100	4	209	25.2	1019.1	0
	700	4	210	25.7	1018.2	0
	1300	5	134	27.2	1017.1	0
	1900	3	128	24.5	1015.0	0
7	100	0		21.8	1014.6	0
	700	3	242	26.0	1014.5	0
	1300	6	154	28.8	1013.3	0
	1900	7	193	28.4	1011.5	0
8	100	6	224	26.7	1010.4	0
	700	7	210	26.9	1009.6	0
	1300	7	206	33.3	1008.0	0
	1900	8	203	29.9	1006.2	0
9	100	1	182	22.6	1006.2	0
	700	7	246	26.8	1006.4	3
	1300	6	240	31.7	1006.8	0
	1900	7	204	29.4	1008.1	0
10	100	7	236	27.2	1009.7	0
	700	4	358	22.4	1013.4	10
	1300	1	136	25.8	1016.8	0
	1900	6	48	24.5	1019.3	0

**Table 3**  
**Meteorological Data (continued)**

Jul 1996						
Day	Hour	Wind Speed m/sec	Wind Direction deg TN	Temperature deg C	Atm Pressure mb	Precipitation mm
11	100	6	79	24.3	1020.8	0
	700	8	90	22.9	1023.6	3
	1300	8	96	24.6	1024.5	0
	1900	8	56	22.9	1023.5	0
12	100	7	81	23.5	1021.3	0
	700	5	112	23.0	1020.8	8
	1300	7	89	23.3	1017.2	0
	1900	17	131	23.7	1009.5	0
13	100	20	190	24.8	1002.6	0
	700	13	242	23.6	1008.6	58
	1300	9	235	30.4	1012.0	0
	1900	8	205	28.6	1012.8	0
14	100	8	218	25.7	1015.3	0
	700	6	225	26.9	1016.3	0
	1300	7	199	31.4	1017.2	0
	1900	6	199	27.4	1017.1	0
15	100	9	217	26.6	1018.4	0
	700	10	203	27.5	1019.3	0
	1300	9	204	30.7	1019.1	0
	1900	10	200	27.7	1018.1	0
16	100	9	225	27.3	1019.3	0
	700	7	251	26.1	1021.9	0
	1300	5	240	28.6	1022.6	0
	1900	6	217	27.7	1021.3	0
17	100	5	212	25.6	1022.4	0
	700	6	251	26.8	1023.0	0
	1300	4	241	31.6	1022.1	0
	1900	1	185	27.2	1020.9	0
18	100	3	246	27.3	1021.7	0
	700	2	239	27.0	1021.6	0
	1300	4	160	28.6	1019.6	0
	1900	5	184	27.4	1017.2	0
19	100	5	71	21.8	1017.9	0
	700	7	215	26.5	1012.7	83
	1300	8	253	32.0	1010.3	0
	1900	7	230	30.6	1007.7	0
20	100	4	283	29.2	1007.1	0
	700	7	350	22.6	1010.7	0
	1300	4	31	24.9	1012.2	0
	1900	1	117	22.9	1012.1	0

**Table 3**  
**Meteorological Data (concluded)**

Jul 1996						
Day	Hour	Wind Speed m/sec	Wind Direction deg TN	Temperature deg C	Atm Pressure mb	Precipitation mm
21	100	2	160	22.3	1014.0	0
	700	5	1	23.6	1015.3	0
	1300	3	83	25.5	1015.8	0
	1900	4	164	24.0	1014.6	0
22	100	4	153	23.5	1015.1	0
	700	3	114	25.0	1014.2	0
	1300	8	147	26.8	1012.3	0
	1900	7	180	27.9	1010.4	0
23	100	3	206	26.7	1009.9	0
	700	4	286	26.8	1010.4	0
	1300	2	25	26.5	1012.0	0
	1900	2	124	24.8	1013.4	0
24	100	2	170	24.0	1014.2	0
	700	3	1	23.9	1015.2	0
	1300	4	1	25.1	1016.2	0
	1900	6	90	24.2	1015.4	0
25	100	0		23.6	1015.8	0
	700	2	50	24.2	1017.1	0
	1300	5	124	26.3	1016.5	0
	1900	5	181	25.6	1014.9	0
26	100	6	217	26.1	1012.8	0
	700	6	276	25.2	1014.1	4
	1300	7	243	28.7	1016.1	0
	1900	5	271	28.3	1017.0	0
27	100	4	265	26.4	1018.7	0
	700	2	347	25.0	1020.5	0
	1300	3	45	26.8	1021.8	0
	1900	4	101	25.1	1022.1	0
28	100	4	94	24.8	1022.8	0
	700	5	158	24.6	1024.3	0
	1300	4	112	26.7	1023.5	0
	1900	7	96	25.0	1022.5	0
29	100	7	115	23.4	1020.9	0
	700	5	261	24.4	1019.9	3
	1300	6	354	26.0	1020.2	0
	1900	5	39	24.0	1020.6	0
30	100	3	115	23.6	1020.3	0
	700	5	199	26.5	1020.2	0
	1300	5	252	31.6	1018.9	0
	1900	7	258	28.2	1018.8	0
31	100	7	232	26.8	1019.0	0
	700	8	238	27.3	1019.3	0
	1300	7	221	32.7	1018.8	0
	1900	7	192	28.9	1017.1	0
		Resultant		Mean	Mean	Total
		2	205	26.1	1015.1	175

# Wave Data

## 3

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Wave data are collected from three different sets of instruments, as shown in Table 1 and Figure 3. The first is an array of fifteen pressure gauges, collectively referred to as gauge 3111 (gauge 111 being one of them). Directional information is computed from these gauges using a iterative maximum likelihood estimator. The second is a Baylor staff gauge (625) and a pressure gauge (641), both attached to the pier. The third is a Waverider buoy (630). The data are collected, analyzed, and stored on optical disc using a Digital Equipment Corporation VAXstation 4000. Data is sampled at 2 hertz, with five contiguous 34 minute records, for a total collection period of nearly 2 hours and 51 minutes. This report reflects the data collection periods of 0100, 0700, 1300, and 1900 EST. The results are based only on the first 34 minute record. The exception is the 8 Meter Array (3111) which condenses the first four records into one statistical value.

Wave height  $H_{mo}$  is an energy-based statistic equal to four times the standard deviation of the sea surface elevations. Wave height reported from the pressure gauge has been compensated for hydrodynamic attenuation using linear wave theory. Wave period is identified from the computation of a variance (energy) spectrum with 60 degrees of freedom calculated from a 34-min record. Peak wave period  $T_p$  is defined as the period associated with the maximum energy in the spectrum.

Table 4 presents the wave heights and periods for each wave record obtained at 6 hr intervals during the month. The monthly means and standard deviations from the means shown in Table 4 are average values computed from this data. Figure 5 is a time history of all  $H_{mo}$  and  $T_p$  values obtained for all gauges.

Differences in wave periods between wave gauges (Table 4 and Figure 5) may be the result of wave breaking, wave reformation, the presence of multiple wave trains containing nearly equal energy, and statistical variations in spectral estimations.

**Table 4**  
**Wave Data**

Jul 1996										
Day	Hour	641 Pressure Gauge		625 Baylor Gauge		3111 8 Meter Array			630 Waverider	
		Hmo,m	Tp,sec	Hmo,m	Tp,sec	Hmo,m	Tp,sec	Dir,TN	Hmo,m	Tp,sec
1	0100	0.19	4.7	inoperative		0.75	8.9	72	inoperative	
	0700	0.34	8.9			0.76	8.9	84		
	1300	0.43	8.9			0.83	8.2	62		
	1900	0.46	9.5			0.78	8.9	78		
2	0100	0.37	7.2			0.70	8.9	74		
	0700	0.42	8.3			0.75	8.9	56		
	1300	0.29	9.5			0.61	9.8	80		
	1900	0.37	8.9			0.60	8.9	86		
3	0100	0.30	9.2			0.60	8.2	100		
	0700	0.37	8.9			0.68	8.9	62	0.10	8.6
	1300	0.31	9.2			0.64	8.9	98	0.74	8.9
	1900	0.38	8.9			0.65	8.9	82	0.73	8.6
4	0100	0.31	8.9			0.51	8.9	100	0.80	9.2
	0700	0.41	4.7			0.56	8.2	96	0.95	8.3
	1300	0.24	8.3			0.41	8.2	76	0.50	8.1
	1900	0.26	8.3			0.46	8.9	90	0.56	8.9
5	0100	0.24	8.9	inoperative		0.41	8.9	100	0.45	8.3
	0700	0.23	7.6			0.46	8.2	98	0.50	8.6
	1300	0.23	9.2			0.44	8.9	82	0.50	8.3
	1900	0.24	8.3			0.43	8.2	92	0.52	8.6
6	0100	0.26	8.9			0.40	8.9	100	0.50	8.9
	0700	0.19	8.9			0.39	8.2	92	0.49	8.9
	1300	0.26	8.9			0.40	8.2	82	0.57	8.6
	1900	0.27	4.7			0.46	8.9	82	0.59	8.9
7	0100	0.39	5.5			0.55	5.6	86	0.73	5.3
	0700	0.25	8.3			0.47	8.2	106	0.55	8.1
	1300	0.27	8.6			0.42	8.9	94	0.49	8.3
	1900	0.21	8.3			0.37	8.9	98	0.55	8.9
8	0100	0.19	8.9			0.34	8.9	80	0.42	8.6
	0700	0.14	8.3			0.32	8.9	88	0.37	9.2
	1300	0.19	8.3			0.31	8.9	88	0.34	8.9
	1900	0.15	8.6			0.25	8.9	70	0.37	8.6
9	0100	0.18	8.3			0.28	8.2	94	0.35	8.6
	0700	0.18	5.5			0.27	8.2	70	0.37	21.4
	1300	0.28	18.3			0.40	18.5	106	0.43	18.3
	1900	0.37	17.1			0.57	15.7	102	0.64	17.1
10	0100	0.50	15.1	inoperative		0.79	15.7	100	0.93	15.1
	0700	0.60	14.3			0.93	13.6	90	0.98	14.3
	1300	0.81	14.3			0.95	13.6	102	1.14	13.5
	1900	0.69	16.0			1.04	15.7	102	1.14	16.0

**Table 4**  
**Wave Data (continued)**

Jul 1996											
Day	Hour	641 Pressure Gauge		625 Baylor Gauge		3111 8 Meter Array			630 Waverider		
		Hmo,m	Tp,sec	Hmo,m	Tp,sec	Hmo,m	Tp,sec	Dir,TN	Hmo,m	Tp,sec	
11	0100	0.89	13.5	inoperative		1.25	13.6	100	1.51	13.5	
	0700	1.00	12.9			1.42	12.0	106	1.63	12.2	
	1300	1.10	11.2			1.49	12.0	106	1.73	12.2	
	1900	1.05	15.1			1.44	13.6	100	1.52	14.3	
12	0100	0.93	7.4			1.33	10.8	102	1.58	13.5	
	0700	0.76	6.6			1.12	9.8	104	1.27	9.9	
	1300	0.87	9.5			1.24	7.1	102	1.36	7.4	
	1900	1.52	9.5			2.64	8.9	98	3.04	8.9	
13	0100	1.26	10.3			2.14	9.8	90	2.72	9.5	
	0700	0.99	10.7			1.02	9.8	92	1.40	10.3	
	1300	0.58	8.9			0.80	8.9	104	0.97	9.2	
	1900	0.72	8.6			0.84	8.2	96	0.96	8.6	
14	0100	0.55	7.6			0.73	8.2	94	0.92	8.6	
	0700	0.56	8.3			0.56	8.2	104	0.72	8.1	
	1300	0.36	5.2			0.55	7.6	96	0.65	7.8	
	1900	0.56	7.0			0.66	7.1	94	0.89	7.2	
15	0100	0.40	5.3	inoperative		0.52	7.6	104	0.80	6.0	
	0700	0.54	7.0			0.56	7.1	112	0.82	6.5	
	1300	0.44	4.8			0.56	7.6	104	0.75	7.4	
	1900	0.58	6.0			0.56	6.2	108	0.91	6.8	
16	0100	0.31	5.2			0.46	7.6	98	0.62	6.6	
	0700	0.37	6.1			0.48	8.9	104	0.59	8.6	
	1300	0.28	5.4			0.49	8.2	104	0.57	8.9	
	1900	0.40	8.9			0.50	8.9	100	0.61	8.6	
17	0100	0.28	5.7			0.44	8.9	108	0.54	8.6	
	0700	0.34	8.6			0.50	8.9	106	0.57	8.9	
	1300	0.25	9.5			0.44	8.9	106	0.53	8.9	
	1900	0.41	8.9			0.46	8.9	108	0.53	8.9	
18	0100	0.26	9.2			0.45	8.9	106	0.51	9.2	
	0700	0.27	8.5	inoperative					0.57	9.1	
	1300	0.23	9.5			0.37	8.9	108	0.45	8.8	
	1900	0.29	8.3			0.38	8.9	106	0.48	7.8	
19	0100	0.27	9.2			0.34	8.9	106	0.48	9.2	
	0700	0.29	7.4			0.33	8.9	100	0.49	8.3	
	1300	0.19	7.0			0.29	8.9	104	0.40	8.9	
	1900	0.25	7.4			0.36	8.2	104	0.41	7.2	
20	0100	0.26	7.2	inoperative		0.36	7.1	110	0.46	7.2	
	0700	0.31	7.6			0.36	3.9	22	0.60	3.8	
	1300	0.33	4.4			0.43	4.4	30	0.58	4.5	
	1900	0.32	4.6			0.44	5.0	32	0.60	4.7	

**Table 4**  
**Wave Data (concluded)**

Jul 1996												
Day	Hour	641 Pressure Gauge			625 Baylor Gauge			3111 8 Meter Array			630 Waverider	
		Hmo,m	Tp,sec		Hmo,m	Tp,sec		Hmo,m	Tp,sec	Dir,TN	Hmo,m	Tp,sec
21	0100	0.34	6.3		inoperative			0.45	5.6	32	0.51	6.5
	0700	0.27	5.5					0.46	5.3	58	0.57	5.5
	1300	0.29	4.1					0.39	13.6	80	0.47	12.9
	1900	0.23	6.1					0.32	13.6	46	0.43	7.2
22	0100	0.25	12.9					0.33	13.6	68	0.39	6.0
	0700	0.20	4.7					0.31	12.0	108	0.39	12.9
	1300	0.35	6.3					0.47	3.9	134	0.64	4.3
	1900	0.57	5.9					0.59	5.9	108	0.80	5.7
23	0100	0.50	5.7					0.53	5.9	102	0.72	5.4
	0700	0.43	5.4		inoperative						0.63	5.5
	1300	0.30	5.1					0.36	7.6	106	0.53	7.4
	1900	0.28	6.8					0.39	7.1	114	0.51	7.0
24	0100	0.39	7.2					0.41	7.6	108	0.57	7.4
	0700	0.28	5.9					0.32	6.6	120	0.51	6.6
	1300	0.32	6.8					0.39	6.6	122	0.51	7.0
	1900	0.35	5.9					0.39	7.1	108	0.66	3.2
25	0100	0.39	6.1		inoperative			0.48	4.4	90	0.63	3.9
	0700	0.32	5.4					0.41	4.4	76	0.53	6.3
	1300	0.35	6.1					0.37	8.2	106	0.50	8.3
	1900	0.38	5.2					0.36	8.2	106	0.62	3.5
26	0100	0.31	6.5					0.36	10.8	72	0.50	8.6
	0700	0.19	6.5	0.12	8.5			0.31	8.2	104	0.41	9.2
	1300	0.28	8.6	0.14	8.6			0.35	8.2	108	0.44	8.1
	1900	0.23	7.8	0.32	8.6			0.31	7.6	108	0.40	8.3
27	0100	0.21	10.3	0.30	9.9			0.32	9.8	106	0.40	9.9
	0700	0.20	4.5	0.33	9.5			0.33	9.8	110	0.39	10.3
	1300	0.25	8.9	0.39	9.5			0.40	8.9	108	0.44	8.3
	1900	0.26	8.6	0.43	9.2			0.37	9.8	106	0.52	8.9
28	0100	0.25	9.2	0.44	9.9			0.39	9.8	106	0.52	9.9
	0700	0.31	9.9	0.51	9.9			0.43	9.8	106	0.59	9.5
	1300	0.35	9.2	0.51	9.2			0.47	8.9	104	0.63	9.5
	1900	0.44	9.5	0.62	9.5			0.48	9.8	106	0.71	9.5
29	0100	0.55	4.2	0.70	4.3			0.61	4.2	134	0.88	4.2
	0700	0.34	8.6	0.47	9.2			0.43	8.9	106	0.57	8.9
	1300	0.22	2.7	0.49	8.9			0.44	8.9	74		
	1900	0.38	4.8	0.58	4.8			0.48	8.9	104	inoperative	
30	0100	0.31	5.5	0.49	4.4			0.49	4.8	40		
	0700	0.38	5.7	0.65	5.7			0.61	5.9	64	0.81	5.5
	1300	0.24	5.2	0.49	5.6			0.49	5.6	58	0.61	5.6
	1900	0.36	5.9	0.50	6.1			0.49	5.9	58	0.63	5.6
31	0100	0.31	5.2	0.40	5.7			0.43	6.2	58	0.56	5.1
	0700	0.27	9.9	0.43	6.1			0.44	6.6	60	0.55	6.5
	1300	0.29	4.7	0.39	9.5			0.43	7.6	62	0.57	7.0
	1900	0.38	8.6	0.46	7.0			0.42	7.1	58	0.70	4.0
Mean		0.39	8.0	0.43	7.9			0.57	8.7	88	0.69	8.6
Std dev		0.23	2.7	0.14	1.9			0.34	2.5	31	0.41	3.0

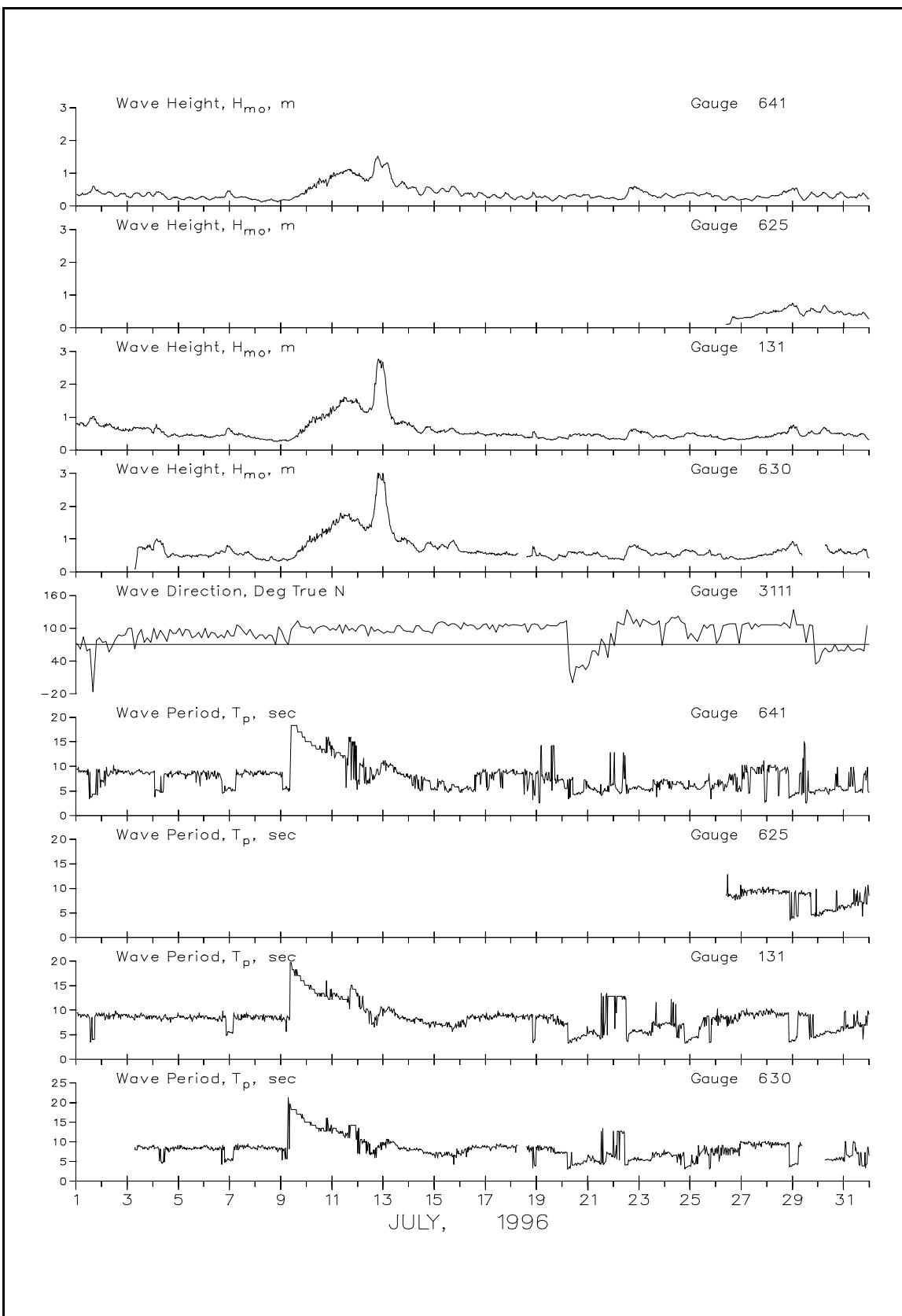


Figure 5. Wave Heights and Periods

# Current Data

## 4

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Current data (Table 5) are collected from a Marsh-McBirney electromagnetic biaxial current meter and by visually observing the movement of small drogues on the water surface in the surf and at the seaward end of the pier, as well as 500 m updrift of the pier, approximately 12 m offshore (Table 6).

Since the shoreline orientation is approximately N20W, longshore currents flow either toward 340 deg (i.e. northward) or toward 160 deg (i.e. southward). Similarly, cross-shore currents are either onshore (westward) or offshore (eastward). All current speeds are given in centimeters per second (cm/sec). Resultant speeds and directions are determined by vector averaging the cross-shore and longshore data. Current directions indicate the direction that the current is moving towards. Current data are plotted in Figure 2.

**Table 5**  
**Current Meter Data - Gauge 3539**

JULY 1996																		
	Cross Long				Cross Long				Cross Long									
Day	Time	Cross Shore	Long Shore	Speed	Dir	Day	Time	Cross Shore	Long Shore	Speed	Dir	Day	Time	Cross Shore	Long Shore	Speed	Dir	
1	100	-1	-2	4	6	1300	0	14	14	157		22	100	-7	-8	12	19	
	700	0	1	1	188	1900	-2	16	16	149			700	-2	-4	5	11	
	1300	-1	0	2	43	12	100	2	19	19	165		1300	2	4	4	182	
	1900	-5	3	6	99	700	-1	12	13	152			1900	0	1	2	103	
2	100	-2	0	3	51	1300	0	0	0			23	100	0	3	3	163	
	700	-4	-6	8	18	1900	-12	-38	41	358			700	1	1	1	205	
	1300	-6	5	9	106	13	100	-8	-56	58	349		1300	0	0	0		
	1900	0	9	9	158	700	4	-30	32	332			1900	-2	5	6	134	
3	100	-1	3	4	121	1300	3	-21	23	332		24	100	-2	3	4	113	
	700	-2	3	4	109	1900	1	-14	15	337			700	1	9	9	165	
	1300	-4	3	5	100	14	100	-2	-19	21	348		1300	-2	6	7	137	
	1900	0	-8	10	343	700	1	-11	12	336			1900	-4	12	13	137	
4	100	-6	-7	10	23	1300	0	-10	11	340		25	100	-2	8	8	140	
	700	-3	18	18	149	1900	0	-11	12	342			700	-5	13	14	135	
	1300	-9	19	21	131	15	100	1	-14	15	337		1300	-8	10	14	119	
	1900	-7	4	9	99	700	1	-9	11	336			1900	1	4	4	177	
5	100	-7	14	16	131	1300	3	-8	9	319		26	100	1	-1	2	303	
	700	-1	2	2	121	1900	-1	-19	20	347			700	1	0	1	249	
	1300	-3	5	6	116	16	100	4	-9	11	321		1300	-3	2	5	99	
	1900	-2	-6	8	4	700	2	-4	5	319			1900	0	3	3	139	
6	100	1	-1	2	324	1300	1	0	1	287		27	100	0	1	1	112	
	700	0	-12	13	345	1900	-2	0	4	54			700	-4	11	12	136	
	1300	-4	-4	7	25	17	100	-1	0	2	81		1300	-2	5	6	127	
	1900	-3	-14	16	355	700	0	0	0				1900	-1	17	17	155	
7	100	-2	-19	20	349	1300	-1	0	2	75		28	100	-1	4	4	139	
	700	-5	-6	9	21	1900	-7	-3	9	41			700	-2	9	10	143	
	1300	0	0	0		18	100	-1	1	3	96		1300	0	4	4	149	
	1900	-1	-3	4	5	700	0	0	0				1900	-1	1	2	92	
8	100	0	-4	5	339	1300	-3	12	13	141		29	100	0	3	3	140	
	700	2	-2	4	312	1900	0	1	1	183			700	1	10	10	167	
	1300	0	-2	3	331	19	100	-3	-1	4	43		1300	-1	2	3	114	
	1900	1	-5	7	328	700	2	-3	5	315			1900	-6	15	16	135	
9	100	0	-7	8	338	1300	1	-2	3	317		30	100	-5	3	7	100	
	700	2	-2	4	307	1900	1	-7	8	331			700	-2	6	7	133	
	1300	0	-5	6	343	20	100	1	-2	3	324			1300	5	5	8	205
	1900	-1	0	2	50	700	-5	-1	6	54			1900	0	1	2	115	
10	100	0	-3	4	340	1300	-2	1	3	83		31	100	3	4	5	191	
	700	0	1	2	111	1900	0	0	0				700	3	1	3	239	
	1300	0	4	4	148	21	100	-1	6	7	145			1300	-4	3	6	98
	1900	-11	8	15	104	700	-4	15	15	141			1900	-1	-2	4	4	
11	100	1	24	24	162	1300	-13	17	21	121								
	700	-4	25	26	148	1900	4	-1	4	279								

**KEY:**

+cross-shore = offshore, cm/sec  
 -cross-shore = onshore, cm/sec  
 +longshore = south, cm/sec  
 -longshore = north, cm/sec  
 Speed = Resultant speed, cm/sec  
 Dir = Resultant direction, degrees true north

**Table 6**  
**Visually Observed Current Data**

Jul 1996												
Day	Pier End				Mid-Surf Zone				Beach			
	Cross Shore	Long Shore	Speed	Dir	Cross Shore	Long Shore	Speed	Dir	Location	Speed	Dir	
1	7	-24	25	357	21	19	28	112	South	10	N	
2	2	-8	8	351	1	17	17	70	South	21	N	
3	7	7	10	115	6	-29	30	351	South	23	S	
4	2	24	25	154	0	15	15	160	North	12	S	
5	6	10	11	129	13	17	22	70	North	17	N	
6	0	-27	27	340	0	-19	19	340	South	17	S	
7	10	-19	21	7	10	-24	26	2	South	12	N	
8	13	-19	23	15	0	-24	24	340	South	27	N	
9	11	-8	14	34	8	-8	12	25	South	5	S	
10	3	21	21	151	0	-51	51	340	North	70	N	
11	-8	18	20	184	0	-87	87	340	South	64	N	
12	-5	-10	11	316	0	-76	76	340	South	49	N	
13	23	-47	52	7	4	-76	76	343	South	50	S	
14	13	-27	30	7	23	-38	44	11	South	34	S	
15	13	-38	40	359	13	-44	45	357	South	53	S	
16	16	18	24	70	11	-11	16	25	South	27	S	
17	6	-5	7	30	14	-11	18	30	South	21	N	
18	7	27	27	146	6	13	14	70	North	8	N	
19	24	-34	41	15	15	-23	27	13	South	23	N	
20	-3	11	12	174	-4	9	10	182	North	11	N	
21	0	61	61	160	0	38	38	160	North	27	N	
22	-5	-17	18	323	-1	-8	8	334	South	23	N	
23	10	11	14	116	3	-7	7	2	South	46	S	
24	-5	14	14	250	1	-13	13	346	South	37	N	
25	-3	25	26	166	11	14	18	70	South	26	S	
26	27	13	30	97	16	7	17	94	North	6	S	
27	0	34	34	160	1	17	17	157	North	0		
28	0	-25	25	340	6	-38	39	349	South	40	N	
29	13	-18	23	15	13	-20	24	13	South	32	N	
30	0	12	12	160	1	-2	2	354	South	3	S	
31	16	-12	20	31	5	-5	7	25	South	6	N	

KEY:

- +cross-shore = offshore, cm/sec
- cross-shore = onshore, cm/sec
- +longshore = south, cm/sec
- longshore = north, cm/sec
- Speed = Resultant speed, cm/sec
- Dir = Resultant direction, degrees true north

# Visual Observations

## 5

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Visual wave direction measurements (Table 7) of both the primary wave train (i.e. that having the higher wave heights) and the secondary wave train (which must be clearly distinguishable as a wave train separate from the primary waves but not surface chop or capillary waves) are taken daily at the seaward end of the pier. The pier axis (considered perpendicular to the beach at the FRF) is oriented 70 deg east of true north; consequently, wave angles greater than 70 deg indicate that the waves were coming from the south side of the pier.

The width of the surf zone (seawardmost breaker position to shoreline) is determined from the pier deck.

Measurements of surface water temperature, density, and depth of visibility are also taken daily at the seaward end of the pier. A Bucket Thermometer is lowered about 0.3 m into the water and allowed to remain for at least one minute. The temperature is then read, and a hydrometer is used to determine the density. A Secchi disc is used to determine the depth of visibility.

**Table 7**  
**Visual Observations**

Jul 1996						
Day	Time	Wave Approach Angle at Pier End deg from True N		Width of Surf Zone,m	Water Characteristics at Pier End	
		Primary	Secondary		Temp.,C	Density g/cc
						Secchi Vis.,m
1	0740	80		30	23.3	1.0216 2.7
2	0620	70	40	26	24.2	1.0208 3.4
3	0605	95		20	21.9	1.0214 1.5
4	0645	35		15	23.3	1.0196 1.8
5	0650	15	75	12	23.1	1.0192 2.1
6	0810	130		12	22.8	1.0197 1.8
7	0810	100		17	23.6	1.0198 2.4
8	0620	120		6	15.0	1.0243 4.9
9	0630	120		9	14.2	1.0247 6.1
10	0615	110		146	14.7	1.0244 4.0
11	0620	95		186	23.6	1.0189 1.8
12	0730	95		125	23.3	1.0186 2.1
13	0820	100		146	16.1	1.0234 0.6
14	0715	105		38	15.0	1.0243 1.2
15	0600	120		40	15.3	1.0243 0.9
16	0615	115		35	14.2	1.0248 2.1
17	0615	120		35	15.0	1.0249 2.1
18	0620	110	90	41	22.8	1.0021 1.8
19	0635	115		37	20.8	1.0214 1.5
20	0750	25		17	19.2	1.0237 4.6
21	0750	25	60	49	21.7	1.0196 2.4
22	0600	50		37	22.8	1.0183 2.4
23	0610	90		43	18.1	1.0239 3.4
24	0556	110	90	26	23.6	1.0208 3.4
25	0620	85		34	23.9	1.0201 4.6
26	0610	105		26	19.4	1.0231 4.6
27	0725	30	90	23	23.3	1.0214 4.9
28	1040	120		58	24.4	1.0186 4.3
29	0500	115		12	24.3	1.0197 4.3
30	0615	80	110	21	24.7	1.0189 4.0
31	0600	100	60	9	23.1	1.0219 3.0

# Water Levels

## 6

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Since 1978, the National Oceanic and Atmospheric Administration (NOAA)/National Ocean Service (NOS) has operated a primary tide station (No. 865-1370) at the seaward end of the FRF pier. A NOS acoustic tide gauge (Next Generation Water Level Measurement System, NGWLMS) is used to collect water level data every 6 minutes throughout the month.

The variation in water level during the month is shown in Figure 6 along with a list of means and extreme values. This presentation is useful in identifying effects of both meteorological and astronomical forces on the open coast water level.

Table 8 contains the range, high, low, and mean water level for each 12.42-hr tidal cycle.

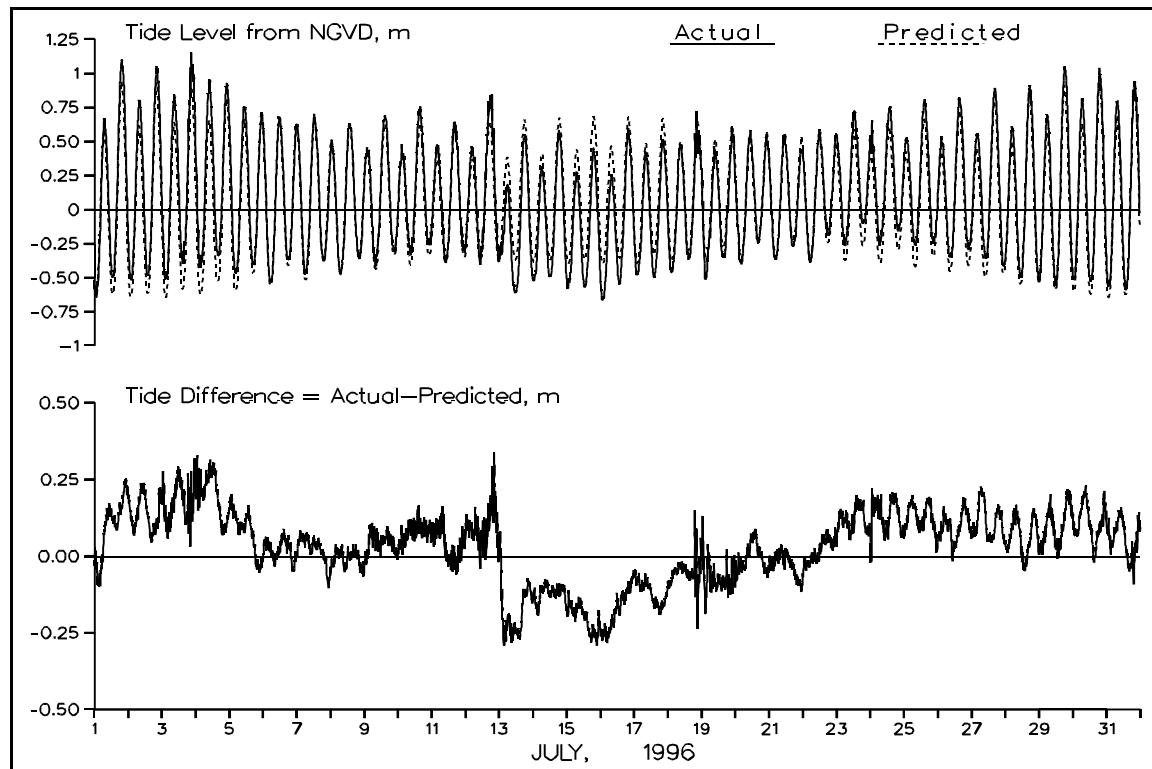


Figure 6. Water Level Variation

**Table 8**  
**Water Levels, m NGVD**

JUL 1996 Tide Levels																
Day	High			Low			Mean	Range	High			Low			Mean	Range
	Time	m	Day	Time	m	Day			Time	m	Day	Time	m	Day		
1	0718	0.67	1	0106	-0.64	0	0.06	1.31	16	1942	0.60	16	1330	-0.55	0.04	1.15
1	1936	1.10	1	1254	-0.50	0	0.31	1.61	17	0800	0.43	17	0154	-0.48	-0.03	0.91
2	0736	0.81	2	0212	-0.52	0	0.16	1.32	17	2018	0.52	17	1418	-0.50	0.02	1.02
2	2012	1.06	2	1406	-0.48	0	0.29	1.54	18	0842	0.48	18	0224	-0.46	0.01	0.94
3	0854	0.85	3	0318	-0.51	0	0.18	1.36	18	2030	0.72	18	1436	-0.37	0.13	1.09
3	2042	1.15	3	1454	-0.40	0	0.35	1.55	19	0854	0.47	19	0236	-0.51	0.01	0.98
4	0954	0.96	4	0336	-0.43	0	0.28	1.38	19	2124	0.61	19	1548	-0.35	0.09	0.96
4	2200	0.93	4	1606	-0.34	0	0.29	1.27	20	1048	0.58	20	0412	-0.40	0.10	0.98
5	1042	0.76	5	0448	-0.47	0	0.16	1.23	20	2224	0.54	20	1606	-0.25	0.15	0.78
5	2300	0.72	5	1642	-0.41	0	0.15	1.13	21	1100	0.55	21	0442	-0.37	0.09	0.92
6	1112	0.68	6	0500	-0.54	0	0.09	1.22	21	2306	0.44	21	1654	-0.27	0.09	0.71
6	2348	0.63	6	1824	-0.37	0	0.13	1.00	22	1148	0.59	22	0512	-0.39	0.11	0.98
7	1212	0.70	7	0554	-0.48	0	0.12	1.18	22	2324	0.56	22	1754	-0.19	0.19	0.75
8	0048	0.51	7	1912	-0.38	0	0.06	0.88	23	1248	0.73	23	0554	-0.26	0.24	0.99
8	1312	0.63	8	0654	-0.47	0	0.10	1.10	24	0106	0.65	23	1824	-0.10	0.22	0.76
9	0148	0.46	8	2030	-0.37	0	0.06	0.82	24	1418	0.76	24	0636	-0.26	0.26	1.02
9	1448	0.69	9	0800	-0.42	0	0.16	1.11	25	0200	0.53	24	1948	-0.16	0.20	0.69
10	0242	0.48	9	2142	-0.31	0	0.07	0.79	25	1436	0.81	25	0742	-0.26	0.27	1.07
10	1554	0.76	10	0848	-0.34	0	0.21	1.09	26	0224	0.54	25	2100	-0.25	0.14	0.79
11	0348	0.48	10	2200	-0.26	0	0.11	0.74	26	1506	0.82	26	0836	-0.35	0.23	1.18
11	1612	0.65	11	1006	-0.39	0	0.14	1.04	27	0400	0.56	26	2148	-0.30	0.15	0.86
12	0418	0.47	11	2336	-0.32	0	0.10	0.78	27	1654	0.89	27	0948	-0.36	0.26	1.25
12	1842	0.84	12	1024	-0.41	0	0.24	1.25	28	0442	0.61	27	2306	-0.41	0.11	1.02
13	0600	0.19	12	2342	-0.38	0	-0.10	0.57	28	1718	0.91	28	1112	-0.50	0.21	1.41
13	1800	0.55	13	1124	-0.61	0	-0.05	1.16	29	0530	0.69	28	2348	-0.53	0.11	1.23
14	0618	0.32	14	0042	-0.52	0	-0.11	0.84	29	1830	1.05	29	1142	-0.56	0.26	1.61
14	1836	0.59	14	1224	-0.50	0	0.04	1.08	30	0700	0.82	30	0042	-0.51	0.17	1.33
15	0642	0.28	15	0042	-0.58	0	-0.13	0.86	30	1906	1.04	30	1236	-0.53	0.25	1.57
15	1854	0.45	15	1236	-0.57	0	-0.07	1.02	31	0754	0.80	31	0118	-0.57	0.13	1.37
16	0818	0.26	16	0124	-0.66	0	-0.19	0.92	31	1954	0.94	31	1348	-0.58	0.19	1.53

# Bathymetry

## 7

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A. Nearshore Profiles. In order to document profile response away from the pier, surveys of four profile lines extending 900 to 1,000 m from shore and located 489 and 581 m north and 517 and 608 m south of the FRF pier are conducted bi-weekly, after storms, and during more complete bathymetric surveys.

These profiles are obtained using the CRAB-Geodimeter surveying system; a Geodimeter 140-T self-tracking, electronic theodolite, distance meter, in combination with the Coastal Research Amphibious Buggy (CRAB), a 10.7 m high, self-powered, mobile tripod on wheels.

Figure 7 shows the last survey in June 1996 and the survey(s) in July 1996 on profile line 188, located 517 m south of the pier.

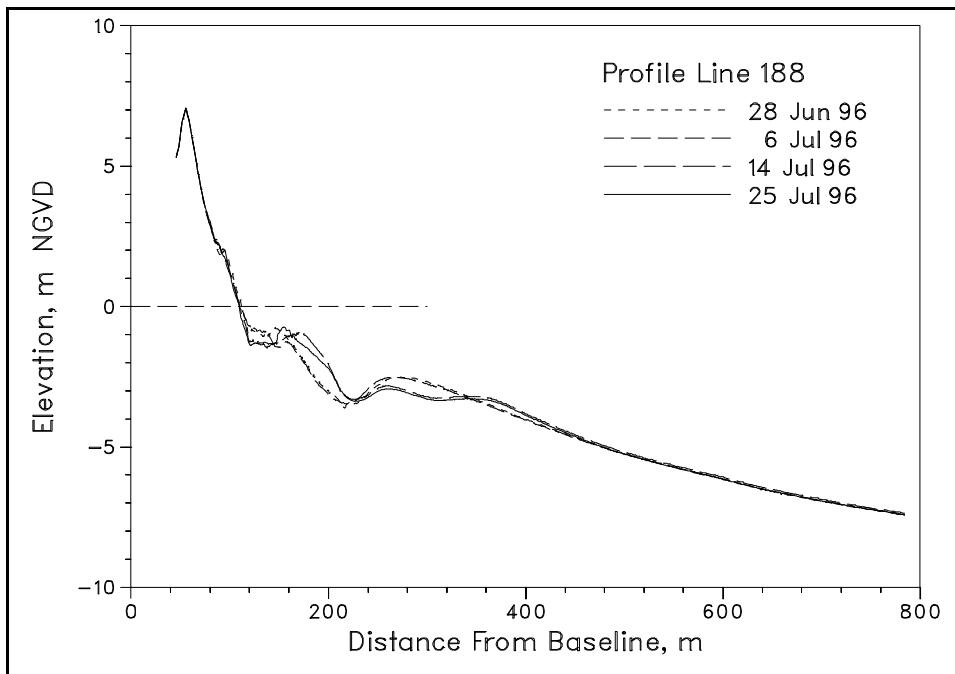


Figure 7. Monthly CRAB Profiles on Profile Line 188.

The profile envelope (Figure 8) reflects the maximum changes that occurred on the profile during 1996. Cross-hatched areas indicate changes to the annual envelope which occurred in July.

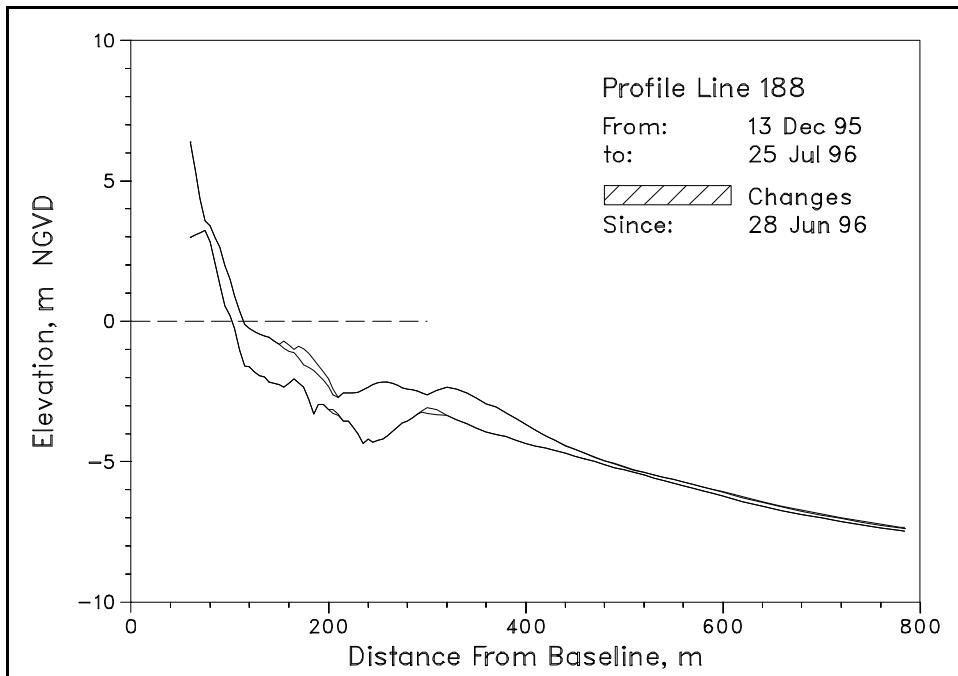
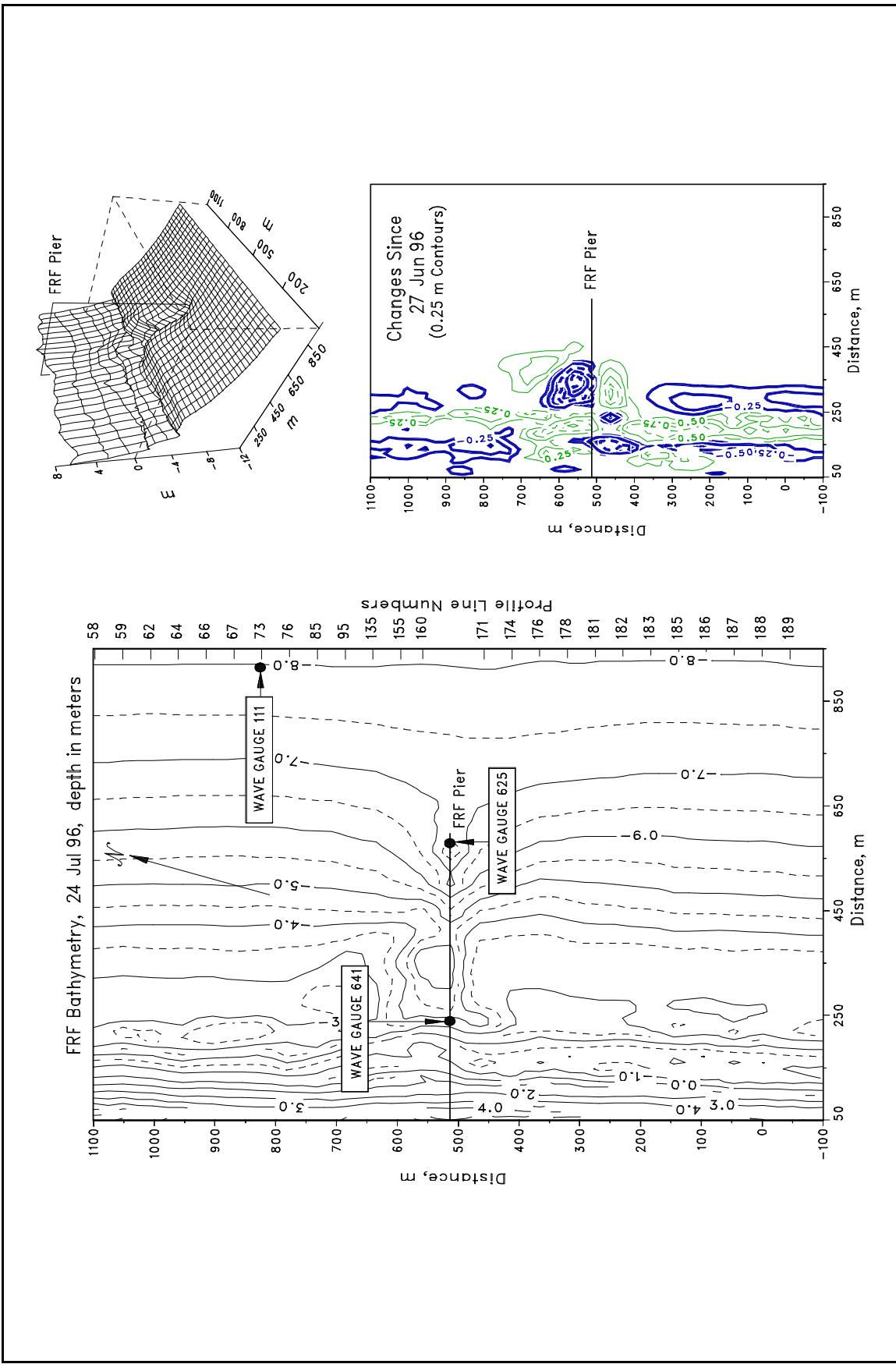


Figure 8. Profile Envelope - Profile Line 188.

B. Bathymetry. Figure 9 includes a two- and three-dimensional contour map and a change plot derived from the bathymetric survey on 24 July. Wide contour lines on the change diagram represent eroded areas; thin lines indicate deposition.



# Special Events

## 8

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A. Storm Data Collection. The following list identifies times when the wave height  $H_{mo}$  at the seaward end of the pier exceeded 2 m.

	<u>Start</u>	<u>End</u>
	12 Jul (1634)	13 Jul (0316)

B. Storm Synopsis.

Hurricane Bertha became a threat to the Carolina coast by the morning of 11 July. Bertha made landfall at approximately 1600 EST on 12 July, near Wilmington North Carolina, approximately 160 km southwest of Cape Hatteras. The storm remained on a northerly course 150km to the west (inland) of Duck, NC.

Maximum onshore winds (NE) reached 21 m/s at 0016 EST on 13 July. The minimum atmospheric pressure was 1002 mb. The maximum  $H_{mo}$ , at gauge 630, reached 3.0 m ( $T_p=8.8$  s) at 2042 EST on 12 July. There was 11 mm of precipitation.